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ISOTROPIC QUARTZ[1]

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It is commonly stated that substances which are isometric and those which are amorphous are isotropic, while all other substances are anisotropic. The purpose of this note is to show that the second part of such a statement is not true in all cases, since hexagonal, and, doubtless all other types of crystals, may be isotropic.

A rock sample from the Bates iron mine at Iron River, Michigan, contained material, not easily recognized, which led to the discovery of isotropic quartz. A thin section showed that the rock was composed of some recognizable quartz in microscopic veinlets and in very small isolated irregular areas scattered through a groundmass which was in large part entirely isotropic. The recognizable quartz passed by all gradations of size into mere points of light in the groundmass. Measurement of the section by the Rosiwal method showed that more than half of it was isotropic.

In order to learn the nature of this isotropic material the rock was next studied in powdered form in immersion liquids and the index of refraction of the isotropic substance was found to be 1.54 ± 0.01. This result showed that the substance was not rhyolite glass (index $1.48-1.50$), nor silica glass (index 1.46), nor opal (index $1.41-1.46$). A partial chemical analysis of the rock was then carried out by Mr. H. G. Taylor, who found that it contained about 0.5% H_2O, and that the anhydrous material contained about 98% SiO_2, while the 2% residue was quite red with iron.

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[1] If an isotropic substance is one which produces no visible double refraction when examined microscopically between crossed nicols, then this quartz is isotropic. On the other hand, if an isotropic substance is one whose smallest units, even though invisible, theoretically produce no double refraction then this quartz is doubtless only apparently isotropic. It is common practice to call substances isotropic, which produce no microscopically visible double refraction.

These results suggested that the isotropic substance might be quartz in such a fine state of division that it did not produce polarization, but nevertheless was distinctly crystalline and not amorphous. In order to test this idea the powdered rock (freed of the larger quartz units and, therefore, decidedly more than half isotropic) was next tested by X-ray methods. Since it was impossible to eliminate all the birefringent quartz from the powder the test was made by comparative methods. One half of the tube which was to be exposed to X-rays was filled with the powdered rock and the other half with pure powdered quartz. The first half of the tube produced the pattern shown in the upper part of Fig. 1, while the second half produced the X-ray pattern shown in the lower part of the same figure. It is evident that the powdered rock not only produced exactly the same X-ray pattern as the pure quartz, but actually produced sharper and brighter lines than the latter. From other X-ray work it is known that the finer the state of division of a powder, the sharper and brighter are the lines produced in the X-ray pattern. Also, any crystalline material in a powder in more than certain minimum amounts will give its own X-ray pattern, and the intensity of this pattern will depend upon the relative amount of the particular kind of crystal (which is producing it) present in the powder. Amorphous material like glass produces no X-ray pattern. If an amorphous powder is mixed with a crystalline powder the X-ray pattern of the latter is correspondingly reduced in sharpness and brightness.

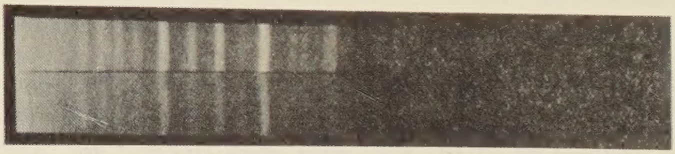

Fig. 1. X-ray patterns produced by powdered rock from the Bates mine (upper part) and by pure powdered quartz (lower part).

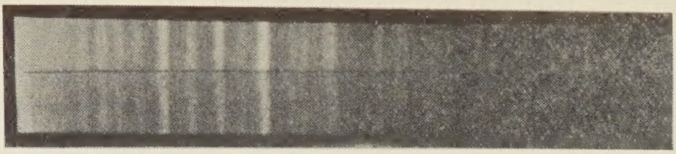

Fig. 2. X-ray patterns produced by pure powdered quartz (upper part) and a mixture of 50% quartz and 50% opal (lower part).

To make the conclusion plainer another tube was filled, one half with pure powdered quartz and the other half with a mixture in equal parts of powdered quartz and powdered opal. This tube gave the patterns shown in Fig. 2, the upper part being produced by the pure quartz and the lower half by the mixture of quartz and opal. It is easily seen that the pure quartz produces a pattern both sharper and brighter than the mixture, though the patterns are otherwise alike, since the mixture contains only one kind of *crystalline* powder.

It is believed that these results demonstrate that the isotropic portion of the rock in question is not amorphous, but is actually quartz, as truly crystalline as that which is anisotropic, although the crystal units must be too small to produce any birefringence, and must, therefore, be small as compared with the thickness (0.03 mm.) of a thin section; they are, however, large as compared with a wave length of the X-ray. Since the thickness of a thin section is about 50,000 times as great as an X-ray wave length, there is a wide range of sizes possible for isotropic quartz.

It is highly probable that many other substances which have been considered amorphous are actually well crystallized. In fact, Hull reported some time ago that many so-called amorphous substances gave good X-ray patterns. Limonite is an example of such a substance. So far as known to the writer, isotropic quartz has not been observed heretofore.

The rock from the Bates mine is not only the first rock known which consists in large part of isotropic quartz, but it is also the first "chert" known from the Lake Superior region which contains isotropic silica in any form.

Cherts of other regions commonly contain more or less isotropic material which has been referred to opal. The observations here recorded, together with the very low tenor of water in these cherts, suggest that isotropic quartz may be wide spread in such rocks.

GANOPHYLLITE FROM FRANKLIN FURNACE, NEW JERSEY[1]

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and

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In a previous paper by the writers[2] on some new specimens of rhodonite from Franklin Furnace, New Jersey, attention was called to a mineral referred to as a hydrous manganese silicate which however could not be identified, optically, as any known mineral. This material was present in very small amounts on two pieces of the rhodonite submitted for examination by Mr. Frederick A. Canfield, on one specimen presented to the Museum by Colonel Roebling and on one submitted for identification by Ward's Natural Science Establishment. Only the latter specimen contained enough of the unknown mineral to warrant a quantitative chemical analysis but only at the sacrifice of the entire specimen. Mr. R. B. Gage manifested an enthusiastic interest in learning the identity of the material and offered to purchase the specimen and surrender it for analysis. The matter was taken up with Mr. George L. English who, after consultation with Mr. Ward, informed the writers that the Establishment would be pleased to contribute the specimen for the purpose of the investigation.

It is a pleasure to here acknowledge the generosity of the Ward's Natural Science Establishment through Mr. Ward and Mr. English, as well as that of Mr. Gage.

The specimen was accordingly broken, and by hand picking and finally purifying by the use of heavy liquids, a sample of the mineral was secured for analysis that weighed 0.0735 grams. This could obviously be used only as a single portion and water consequently had to be determined by loss on ignition and, since the manganese was oxidized, as shown by the blackening of the ignited powder, the water determination doubtless gave low results. The analytical results are given below as well as those of the original Paisberg ganophyllite:

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[1] Published by permission of the Secretary of the Smithsonian Institution.

[2] *Am. Min.*, 7, 152, (1922).

	1. Franklin Furnace	2. Paisberg.	3. Theory.
SiO_2	39.18	39.67	40.5
Al_2O_3	8.57	7.95	8.6
Fe_2O_3	trace	0.90	——
MnO	36.33	35.15	41.8
ZnO	3.67	——	——
CaO	2.04	1.11	——
MgO	——	0.20	——
Na_2O	——	2.18	——
K_2O	——	2.70	——
PbO	——	0.20	——
$H_2O+110°C.$	5.70	9.79	9.1
$H_2O-110°C.$	1.63		
	97.12	99.85	100.0

Aside from the low water shown by the ignition loss of the Franklin Furnace material, the agreement is very close. The analysis furtber serves to confirm the unique composition originally given for this mineral and shows that the alumina is an essential, integral part of the mineral.

Since the indices of refraction of the Franklin material were very different from those of the original ganophyllite,[3] new determinations were made on the specimen of Paisberg ganophyllite from the Holden Cabinet in the Harvard collections. The indices of refraction of a specimen of ganophyllite from Paisberg kindly loaned us by Col. Roebling are somewhat higher, $\beta=1.608$. All the optical data are given below:

	Franklin (Larsen)	Paisberg (Larsen)	Paisberg (Hamberg [4])
Character	Biaxial negative	Biaxial negative	Biaxial negative
2E	Very small	42°	41°53′
2V	Very small	26°	23°52′
Dispersion	$\rho<\nu$, rather strong;	$\rho<\nu$, easily perceptible;	$\rho<\nu$
Refractive Indices			
	$\alpha=1.563$	1.573	1.7046
	$\beta=1.593$	1.603	1.7287
	$\gamma=1.593$	1.604	1.7298
Birefringence	$=0.030$	0.031	0.0252
Cleavages	⊥ to Z	⊥ to X and Z	⊥ to X

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[3] Hamberg, A., Mineralogische Studien, *Geol. Foren, Förh,* **12,** 588, (1890).

[4] Hamberg, A., *Loc. cit.*, p. 589. The values of β and γ were determined on a prism with 30° angle but as no good polish was possible because of the perfect cleavage, a piece of cover glass was attached to the surface.

The agreement between the optical properties of the two is sufficiently close to show that the Franklin Furnace mineral is unquestionably identical with the very rare mineral ganophyllite. Palache[5] had previously identified ganophyllite from Franklin Furnace. Additional notes on the optical properties, pyrognostics, etc., as well as the occurrence, are given in the paper referred to above.

[5] Palache, Chas., Contributions to the mineralogy of Franklin Furnace, N. J.: *Am. J. Sc.*, *XXIX* 187 (1910).

THOMSONITE FROM PEEKSKILL, NEW YORK

Alexander H. Phillips, *Princeton University*

Several years ago a party of students on a field trip near Peekskill collected some specimens of thomsonite, and I believe this is a locality from which it has not heretofore been reported. Locally it occurs two miles east of Peekskill and about five hundred feet south of Dalton's emery quarry, in an area termed pyroxenite by G. S. Rogers,[1] in his paper on the "Cortland series and its emery deposits." He however mentions a mineral occurring in some of his sections of a sodalite syenite, lying near the thomsonite locality, which from its optical properties he thought might be thomsonite, and from its hexagonal outline was believed to be a secondary product from nephelite.

Occurrence. The thomsonite occurs in irregular angular cracks, possibly shrinkage cracks, which in some cases possess scoriaceous walls. It was preceded in its crystallization by some unknown mineral of tabular habit, the presence of which is now recognized by solution cavities both in the thomsonite and between it and the rock walls of the cavities. The thomsonite is of the usual radiated habit, some of the rays reaching four inches in length but without crystalline terminations. Now that the tabular mineral has been dissolved it is associated with no other mineral, but is coated with a thin film of a light colored clay, which has been mechanically washed into the cavities and gives the crystals a light yellowish color, but underneath this thin film the mineral is white and transparent with numerous capillary cavities elongated parallel to the vertical crystallographic axis, causing a slight silky luster.

[1] G. S. Rogers, *Annals N. Y. Acad. Sci.*, *XXI*, 11, (1911).

Several specimens of analcite were obtained from the same locality, but these two zeolites occupied separate and distinct cavities, at least in the specimens obtained, with one exception where there are several crystals of analcite occupying a solution cavity and plastered or spread out on the walls of thomsonite forming the cavity, seeming to indicate that the crystallization of thomsonite, in the cooling of a rock mass, is earlier or prior to that of analcite.

If this is the case, thomsonite is one of the earliest zeolites to crystallize. Fenner states, in the Watchung Basalt,[2] analcite and natrolite are the first to crystallize but does not mention thomsonite, which is a rare mineral in that locality.

COMPOSITION. The analysis of this thomsonite shows that it is almost exactly the composition of the theoretical molecule that Dr. Wherry[3] has calculated for thomsonite, of the proportion of $Na_2 : Ca = 1 : 4$, as follows:

	Theoretical	Peekskill	Kilpatric, Scotland
SiO_2	37.3	37.44	37.21
Al_2O_3	31.6	31.57	31.79
Fe_2O_3	——	.08	——
CaO	13.9	13.80	13.60
Na_2O	3.8	3.98	4.20
K_2O	——	.04	——
H_2O	13.4	13.22	13.27
	100.00	100.13	100.07

The specific gravity is 2.3860 at 20°C.

The indices of refraction were determined, with a Fuess reflectometer, on polished oriented surfaces to be $\alpha = 1.527$, $\beta = 1.531$, $\gamma = 1.543$. These values are a little higher than any given by S. G. Gordon,[4] but this specimen contains more calcium than any in his list. The nearest is that from Kilpatric, Scotland, the indices of which are $\alpha = 1.529$, $\beta = 1.531$, $\gamma = 1.541$ and the analysis as given by Dana is as above.

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[2] C. H. Fenner, *Annals N. Y. Acad. Sci.*, *XX*, No. 2, pp. 95-187.

[3] Edgar T. Wherry, Notes on the Composition of Thomsonite. *Am. Min.*, **8**, 121 (1923).

[4] S. G. Gordon, Optical Notes on Thomsonite. *Am. Min.*, **8**, 125, (1923).

COPIAPITE FROM THE SANTA MARIA MTS., EASTERN RIVERSIDE CO., CALIFORNIA

J. F. Schairer and C. C. Lawson, *Yale University*

Several specimens of a ferric sulphate were received by the Brush Mineral Collection several years ago from Mr. L. J. Childs of Rialto, California. These specimens were preserved under a bell jar to prevent alteration. Recently the writers have examined this material and selected pure material for analysis.

The mineral, which proved to be copiapite, is from the Santa Maria Mts., Eastern Riverside Co., California. It is yellowish brown in color and has a crystalline structure. With the copiapite occurs amarantite and an altered white mineral which could not be identified. The copiapite proved upon microscopic examination to be homogeneous and free from other minerals.

Professor W. E. Ford examined the mineral optically and reports that it is biaxial, optically positive, alpha undetermined, beta equal to 1.53, and gamma equal to 1.57; pleochroism Z equals yellow and Y nearly colorless. Possesses one perfect cleavage normal to obtuse bisectrix.

The analysis was made of the purest material carefully selected and preserved from any dehydration in a tightly stoppered specimen tube. Insoluble material, ferric oxide, calcium oxide, and magnesium oxide were determined by the standard methods. Aluminium oxide, ferrous oxide and alkalies were absent. It was realized that the determination of water was most important and that a very careful and accurate determination was necessary. Water was determined by heating a weighed sample over which a current of *dry* air was led and passing the water vapor given off thru a layer of heated anhydrous sodium carbonate to remove any sulphuric anhydride and collecting the water in weighed calcium chloride and phosphorus pentoxide tubes.

The analyses and ratios are here quoted:—

	I	II	Mean	Molecular ratios	Revised ratios
Fe_2O_3	26.46%	26.32%	26.39%	0.166	0.166 equal 2.00
SO_3	39.64	39.93	39.79	0.497	0.413 equal 4.97
H_2O	29.99	29.85	29.92	1.661	1.582 equal 19.03
CaO	0.30	0.24	0.27	0.005	
MgO	3.20	3.18	3.19	0.079	
Insoluble	0.30	0.29	0.30		
Total	99.89%	99.81%	99.86%		

The magnesium oxide and calcium oxide are considered as impurities and the magnesium oxide subtracted as kieserite ($MgSO_4.H_2O$), and the calcium oxide as anhydrite $CaSO_4$, to obtain the revised ratios. The molecular ratios are then 2 Fe_2O_3. 5 SO_3. 19 H_2O which we propose to write $Fe_4(OH)_2$ $(SO_4)_5$. 18 H_2O.

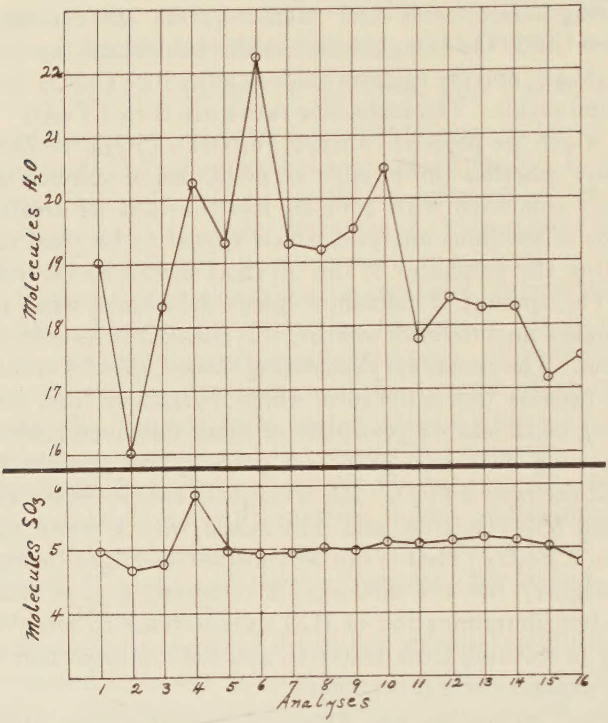
To show whether the number of molecules of sulphur trioxide and water combined with 2 Fe_2O_3 was constant we recalculated the ratios of previous analyses which appear to be most reliable, subtracting the sulphates of the bivalent metals as the monohydrate. The amount of calcium sulphate is so small when present that it makes no difference whether it is considered as anhydrite or as gypsum. The reason for considering these sulphates as monohydrates is because this is the form which crystallizes from solutions containing considerable quantities of other dissolved substances.[1] The following data and graphical presentation (Lower Figure) show that the ratio 2 Fe_2O_3 : SO_3 is constant except for one analysis which had 5% insoluble, and was mixed with a white mineral. The ratio 2 Fe_2O_3 : H_2O is not as constant as might be expected (Upper Figure), but the difficulty in obtaining a good water determination (determination of H_2O by difference in many cases), difficulty in securing fresh material, and the low molecular weight of water explain these divergences.

Scharizer[2] recognizes two types of copiapite—one free from bivalent metals, and the other containing them. We cannot accept this distinction and prefer to regard bivalent bases as impurities present as the hydrated sulphates until it can be definitely established by experiment that ferric sulphate can form addition products with bivalent sulphates. This could be shown quite definitely by means of a solubility diagram but at present this data is lacking.

There is considerable work still to be done on the hydrated sulphate minerals. When suitable material becomes available we hope to continue our work. Others who have at their disposal unaltered material should help to establish the chemical composition and relationships of these minerals. In conclusion we wish to acknowledge our indebtedness to Professor H. W. Foote for his inspiration, suggestions and criticism.

[1] Foote and Scholes: *J. Am. Chem. Soc.*, **33**, 1309 (1911).

[2] Scharizer: *Zeit. f. Kryst.*, **52**, 372 (1913).



Analyses Graphed

1. Schairer and Lawson: Santa Maria Mts. Eastern Riverside Co. Cal. This paper.
2. Darapsky: Tierra amirilla, *Jahrb. Min.*, **1**, 62, (1890).
3. Melville and Lindgren: Sulphur Banks Cal., *U. S. Geol. Surv., Bull.* **61**. (1890).
4. Schaller: Leona Heights, Alameda Co. Cal., *Bull. Dept. Geol. Univ. Cal.*, **3**, 214, (1903). Few prisms of a colorless white mineral intermixed.
5. Melville and Lindgren: Knoxville Cal., *U. S. Geol. Survey, Bull.* **61**, (1890).
6. Mauzelius: Falun, *Geol. Fören. Förh.*, **17**, 306, (1895).

7&8. Scharizer: South America, *Zeit. Kryst.*, **52**, 372, (1913).

9&10. Scharizer: Rammelsberg, *Zeit. Kryst.*, **52**, 372, (1913).

11. Makintosh: Tierra amarilla, *Am. J. Sci.*, **38**, 245, (1889).
12. Ahrend and Ulrich: *Rammelsberg Zeitschr. f.d. ges. Naturw. Halle*, **3**, 32, (1854).
13. Linck: Chili, *Zeit. Kryst.*, **15**, 17, (1888).
14. Scharizer: Sierra de L'Alcapa rossa, *Zeit. Kryst.*, **52**, 372, (1913).
15. Posnjak and Merwin: Artificial, *J. Am. Chem. Soc.*, **44**, 1965, (1922). This preparation may have been somewhat dehydrated by washing with alcohol and ether.
16. Scharizer: Artificial, *Zeit. Kryst.*, **52**, 372, (1913).

CORRECTIONS TO VOLUME 9.

No. 1, p. 4, End of first line of analysis, transpose 1 and 6.
No. 1, p. 11, line 8 from bottom, for "positive optical character" read "negative optical character."
No. 2, p. 25, line 6 should be omitted entirely.
p. 34, line 12, formula should read $C_{15}H_{20}$.
No. 3, p. 50, line 3, for "conbination" read "combination."
p. 59, first line of table, for "tota" read "total."
p. 66, line 14, for "Thompson" read "Thomson."
p. 67, lines 24 and 25, for "Peeksville" read "Peekskill."
p. 73, line 20 from bottom, for "Unding" read "Ussing."
No. 4, p. 83, footnote 25, for "$5x10^{-3}$" read "$5x10^{-5}$".
p. 86, footnote 31, for "Lotha" read "Lothar."
p. 90, line 2 below first table, for "$4CaO.7SiO_3.5H_2O$" read "$4CaO.7SiO_2.5H_2O$."
p. 99, line 6, insert "Mine" after tungsten.
p. 99, fifth abstract, for "Ordivician" read "Ordovician."
No. 5, p. 116, 14th line from bottom for "Jagger" read "Jaggar."
p. 119, third abstract, for $-/_2$ read $-\frac{1}{2}$.
p. 121, fifth abstract, for "Valenton" read "Voleton."
No. 6, p. 129, 14th line, for "Procelain" read "Porcelain."
No. 7, p. 154, 21st line, delete the parenthesis after $BaCO_3$.
p. 156, the mineral name chinkolobwite should be placed in quotations.
No. 8, p. 167, 6th line from bottom, for "able" read "table."
p. 173, 6th line from bottom, for " E. B. Samson" read "Edward Sampson."
p. 174, 3rd line from bottom, for "therfore" read "therefore."
p. 175, 7th line from bottom, for 7, 47, 6 read 7, 66.
No. 9, p. 183, 9th line from bottom, for "charactristic" read "characteristic".
p. 196, line 7, for "traps" read "trap minerals."
12th line from bottom, for "luna" read "lunar."
p. 197, 2nd line from bottom, for "that" read "the."
No. 10, p. 204, 12th line from bottom, for "deposite" read "deposit."
No. 11, p. 229, 10th line from bottom, for "variety" read "variation".
p. 231, 2nd line from bottom, for "alo" read "also" and for "July 2tho" read "July 20th to."
p. 234, line 4, for "dtermined" read "determined."
line 8, for HCL read HCl.

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Prepared by Edw. F. Holden

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